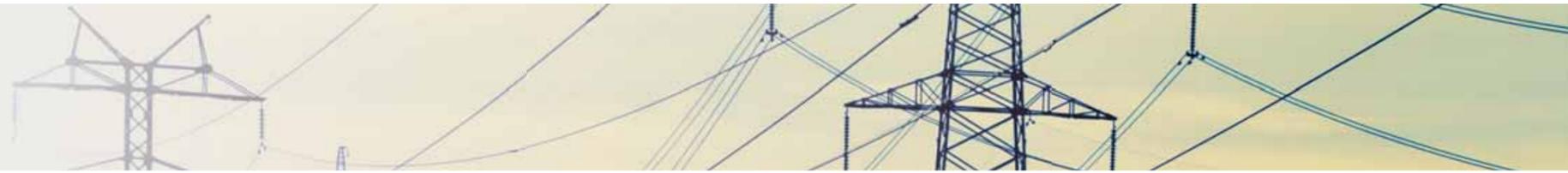


Basic knowledge

Internal reactions and methods of sections for bars, beams and cables



The support structures are composed of different structural supporting elements. The supporting elements are divided into one-dimensional (bar or beam), two-dimensional (plate or disk) and three-dimensional elements (solid-supporting structure).

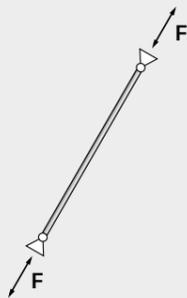
To investigate internal reactions in components or mechanical systems, these are reduced to a few important properties through modelling. Geometric idealisation then eliminates seemingly insignificant dimensions. Instead of three-dimensional supporting elements, two-dimensional supporting

elements/plane-supporting structures (plates, disks and frames) and one-dimensional supporting elements/linear structures (beams, bars, arches and cables) are considered. In this chapter, we look at one-dimensional supporting structural elements.

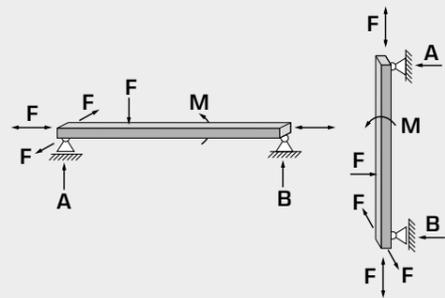
Free-body diagrams are the main method to represent the internal force states in bars, beams and cables. For beam-structures in particular, free-body diagrams are used to characterise the internal stress state and, consequently, are used when dimensioning the beam. Considering the internal forces is a prerequisite for calculating deformation and investigating

the load-bearing capacity of materials as a measure of their strength. When designing components, the internal forces provide the designer with the crucial indicators for necessary dimensions or the type of load distribution.

One-dimensional supporting elements

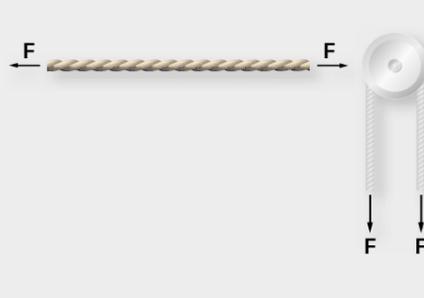


Bar: A support element, flexibly mounted at both ends, which can transfer tensile and compressive forces along the bar axis. Depending on whether a bar transfers tensile or compressive forces, it is referred to as a tension bar or a compression bar.



Beam: Rectilinear supporting element that can transfer forces along its axis, transverse to its axis and moments. Horizontal elements are generally known as beams or girder and vertical elements are known as pillars or columns.

F forces, M bending moment, A, B support forces



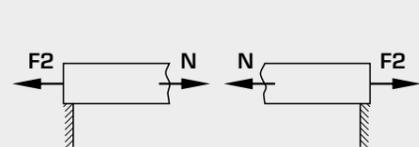
Cable: A support element that can only transfer tensile forces. A cable that is attached at two defined points is the equivalent of a tension bar.

Internal forces

Using notional sections, parts are cut out of the support structure, which is in equilibrium. To maintain equilibrium, the internal reactions, also known as section reactions or internal forces, are entered into the sections. In statics, the internal reactions

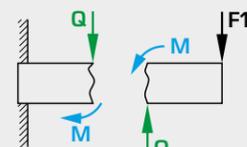
show the forces and moments within a component as a reaction to the action of the external forces.

Normal force



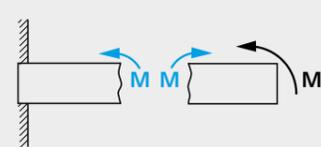
The normal force runs in the direction of the beam axis. This force causes a change in the beam length through an internal reaction to tensile or compressive external forces acting on the beam.

Shear force



The shear force is perpendicular to the normal force. This force results in shear deformation and is the beam's internal reaction to the acting transversal forces.

Bending moment



The bending moment runs around the centroid of the section. This moment causes the beam to bend as a reaction to (tensile and compressive) forces acting on the beam from the outside.

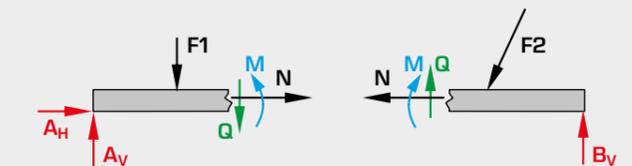
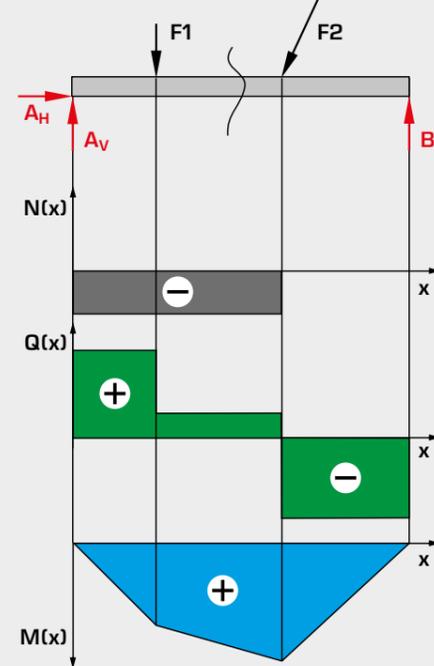
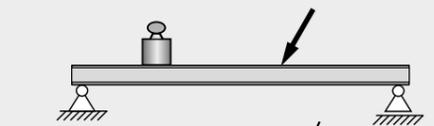
F1 force, F2 tensile force, M bending moment, N normal force, Q shear force

Internal reactions

1. The studied bodies or mechanical systems are removed from the environment through representation in the **free-body diagram**.

2. All forces acting on the body or system are determined. Especially where the body or the mechanical system under investigation is separated from adjacent bodies. Since the internal forces change between the different cross-sections, we plot their curves for a better overview. The shear force, normal force and bending moment are represented as areas.

3. Unknown forces are calculated using the equilibrium conditions.



Supporting structure

Internal forces on a beam

N normal force, Q shear force, M bending moment, F external forces, A, B support forces (support reactions)

Equilibrium condition

A body or a mechanical system is in equilibrium when the effects of all applied forces and moments cancel each other out.

$$\sum F = 0 \quad \sum M = 0$$